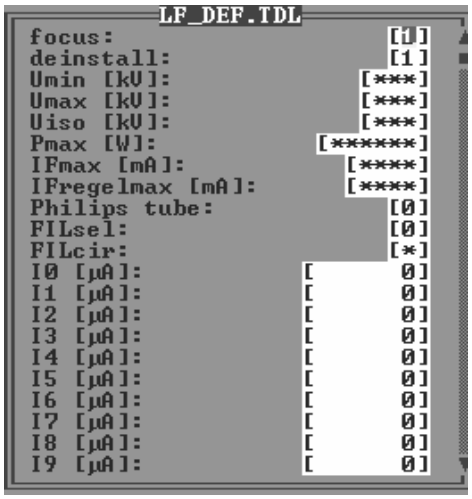
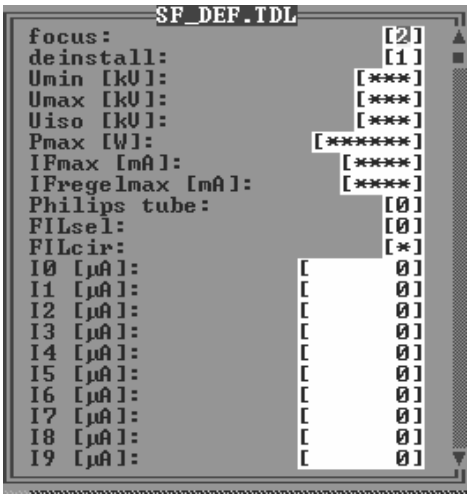
OPTIMUS adaptation sequence

Prerequisites to adapt a tube:

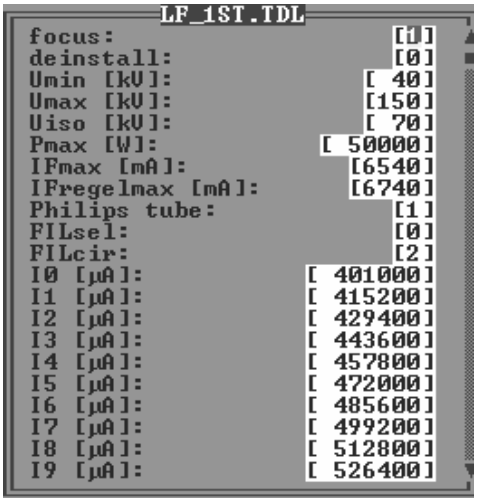
At least one registration device (RGDVx Data Set A) and a tube type must be programmed (followed by a generator reset) to get the generator into a standby condition for adaptation.

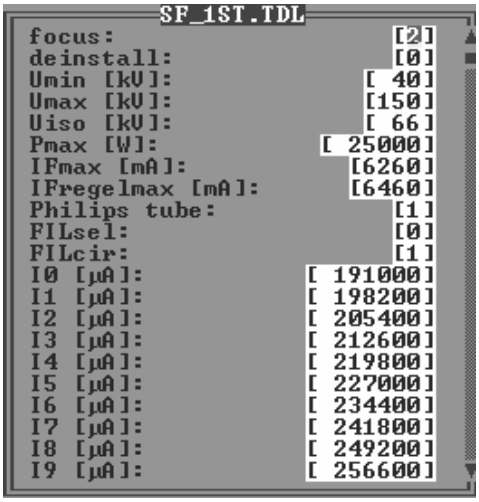
If no tube is programmed the tables of FU-mA (function unit mA_control EZ119) will be empty.
Path: XRGSCOPE >> Select Unit >> FU-mA >> FU-mA >> Program >> Read Focus Limits.
Type in:**1**, 3, 5 for **large focus** tube **1**, 2, 3 or **2**, 4, 6 for **small focus** tube **1**, 2, 3.





Once a tube is programmed the tables look like this (example of an SRO25/50, only part of the table):





Both filaments get default max mA data between 40...150kV represented by the **I0, I1, ... I110 [µA]** values. These are the absolute kV dependent emission current limits. They might be overridden if the max emission current of the generator is smaller (650mA Optimus 50kW, 900mA Optimus 65kW).

Other limits within which the tube will be adapted are

Pmax [W] max focus load (if not overridden by the max generator power)
Ifmax [mA] max filament current limit

Other values which might change during the adaptation process.

Ifregelmax [mA] is a max value which might temporarily be used for fast mA control, typically $I_f$max + 200mA
Uiso [kV] is the default kV value from which on (going to the higher kV stages) the filament current can be decreased achieve always the max possible emission current

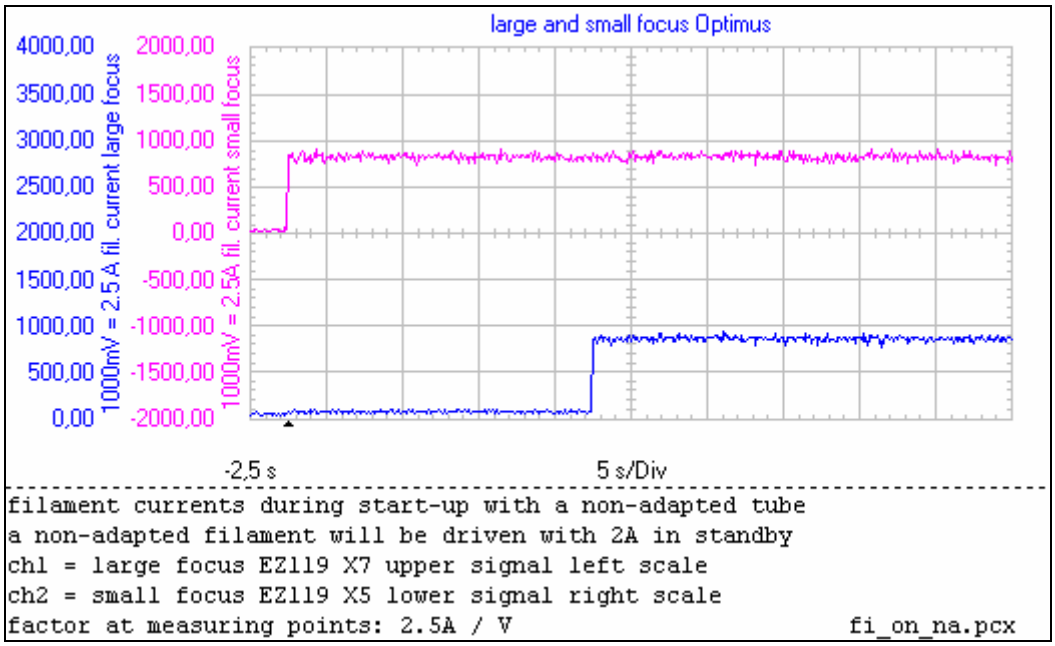
After loading of the tube data and assigning the tube to at least one RGDV the generator must be reset.

It takes longer for the generator to come up if filaments are not adapted; once adaptation has been carried out the up time is much shorter.

A non-adapted tube will get a standby current of 2A at both filaments; with an oscilloscope one can monitor the currents coming up at turn-on.

Numbers in the circles correspond to the overview chart last page.

1



The control desk will display "Test" in the exposure parameter display to indicate that the selected focus is not adapted.

In this stage one can already switch exposures at any kV stage with a special mAs technique (see appendix A **mA_control EZ119 functions conditioning mode**), e.g. to warm up the tube before adaptation.
Conditioning is recommended to avoid arcing problems during adaptation.

In the non-adapted status one will face the following symptoms:
- APR cannot be selected
- No AEC and no non-AEC technique can be selected
- Variofocus cannot be selected (both filaments must be adapted).

5 filament current values are important to know:

1)	I_f min	minimum filament current 500mA which will always be present to feed a grid switch control unit (not for Optimus RAD - R/F- C)
2)	I_f standby	standby filament current (determined during adaptation)
3)	I_f max	maximum filament current
4)	I_f regelmax	maximum filament current + xxx mA offset filament current for fast emission current control in case of mA deviations
5)	I_f boost	boost current = maximum filament current (I_f max) + 2 A

Once adaptation is started via XRGSCOPE and by pushing PREP and EXP the filament current of the non-selected focus will be turned off.
The generator switches automatically to the focus, which has been selected for adaptation.

(2)

The selected filament will get 500mA for a certain time to let it cool down.

With the first exposure at 40kV the mA measuring circuit offset will be measured.
The offset value combines a basic 4mA current driven by the voltage to frequency circuit (waveform see Appendix B) and the additional mA driven by the HT divider circuit, which also passes the mA measuring resistor.

(3)

This offset mA value will be subtracted from the measured mA value during fluoro or exposure.

(4) >> (5)

The second exposure of the adaptation process is 6 seconds long.
At 40kV FU-mA determines a filament current which is necessary to drive an emission current of 100µA.
The filament current value, which has been measured, is the individual standby filament current.
(These values are higher compared to predecessor generators; they were based on a 40µA emission current).

(6)

The filament will now be driven up to its maximum current and will be kept some seconds to get a stable temperature.

Starting at 40kV with slight kV increments FU-mA measures the mA values at each kV stage set.
All exposures of the following sequence will be about 10ms long.

The kV values are increased to a max value to prevent focus overloads.
In the beginning of the adaptation process it will be below 50kV.

Once the focus load limit is attained the filament current will be decreased, a little pause allows the filament temperature to cool down.

A new series of exposures starts again at 40kV with kV increments up to the max focus load.

(7)

At a certain point (once the filament current value is low enough) the max kV value, which has been programmed, can be switched.
From this point on the kV discharge time will get longer with each filament current decrement.
Therefore is important to use CTRL_X_C/ EZX74 as trigger signal.
Using the kV waveform as trigger will fail in the low filament current value exposures.

120 ... 130 exposures will be switched until the filament current is down from its max value in the beginning to the standby value which has been determined before.

(8)

Now FU-mA calculates the kV dependent filament <-> emission current tables.
It also evaluates the new value of the U_{iso}.

The kV value U_{iso} is the kV stage at which the boost adaptation takes place.

(9)

First the positive boost will be carried out. The kV will start (with the U_{iso} value).
Once the kV are up the filament current value will change from its standby value to the
I_f boost value = maximum filament current (I_f max) + 2 A.

FU-mA measures the rising emission current as well as the time it takes to be at the max emission current specified for the U_{iso} value.
This timetable is needed to get the temperature of a filament up as fast as possible if a higher mA value is required.

(10)

The filament current is reduced to 500mA for a certain time to let it cool faster, afterwards it returns back to its standby value.

(11)

A new function of the Optimus is the negative boosting.

(12)

The filament gets the max current for a certain time to have a stable temperature at the filament.
Once the kV are up with the U_{iso} value

(13)

the filament current instantly drops down to the I_f min value of 500mA.

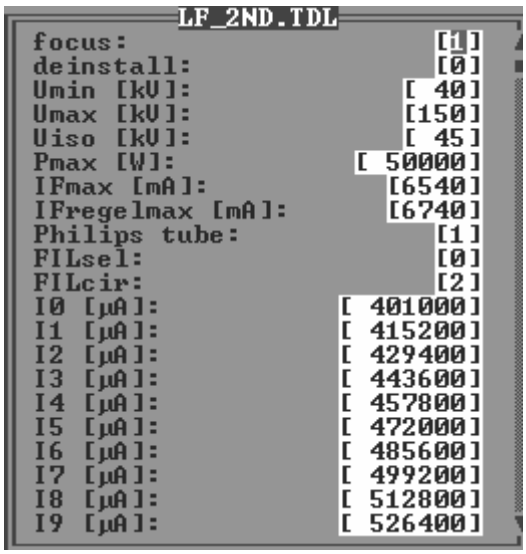
FU-mA measures the falling emission current as well as the time it takes to be down at 100µA.
This timetable is needed to get the temperature of a filament down as fast as possible if a lower mA value is required.

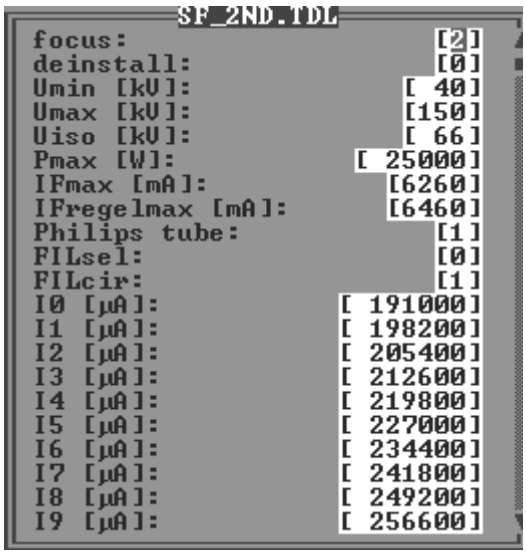
(14)

Adaptation is finished. FU-mA now drives the standby filament current.

The PC will beep; the generator has to be reset now.

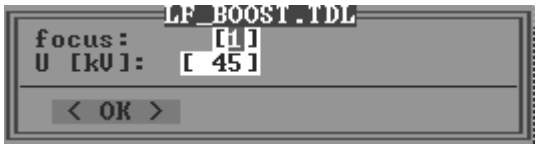
Once both filaments have been adapted one can see in the tables that the kV dependent emission currents did not change (in this case).
The U_{iso} value changed at the large focus, it dropped from 70kV default to 46kV.

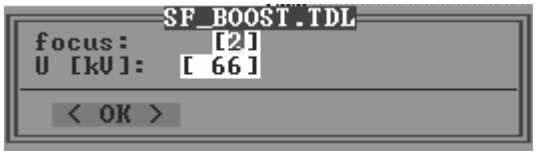




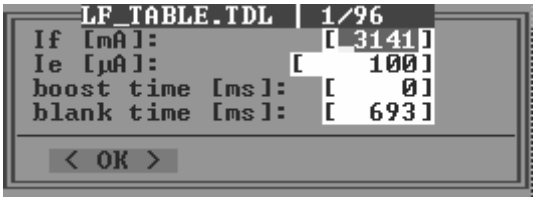
A big amount of data is now present for both filaments. Tables for each kV stage within the min and max programmed kV values are available.

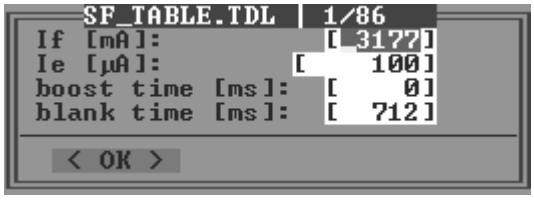
Path: XRGSCOPE >> Select Unit >> FU-mA >> FU-mA >> Faultfind >> Adaptation Results >>
>> Select Adaptation Table for Reading >> Read Previously Selected Adaptation Table





After typing in the filament number and the desired kV stage one gets the tables:
Path: XRGSCOPE >> Select Unit >> FU-mA >> FU-mA >> Faultfind >> Adaptation Results >>
>> Select Adaptation Table for Reading >> Read Previously Selected Adaptation Table





One can only see one data set at once.
With the <page up> or <page down> keys one can step through the table which looks like that if the saved screen (using <F3>) has been imported to EXCEL:

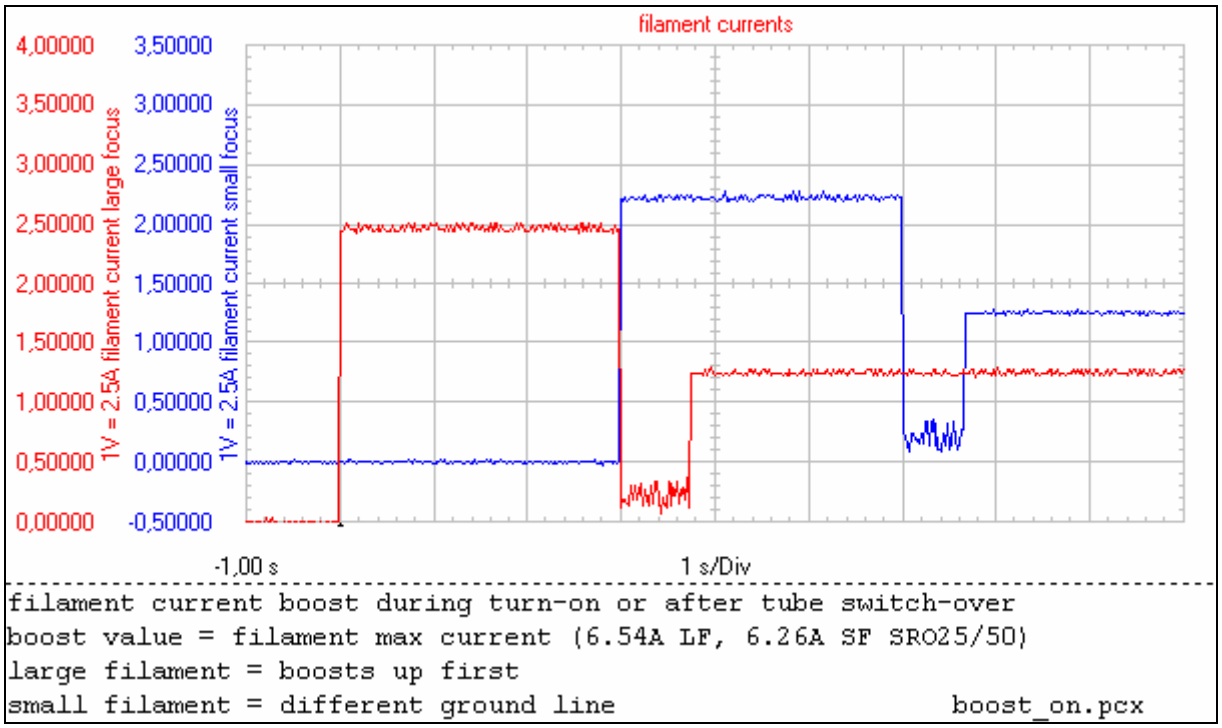
large focus			
If (A)	Ie (µA)	boost time (s)	blank time (s)
3141	100	0	693
3176	126	6	679
3211	153	12	668
3246	182	12	657
3281	214	12	646
3316	250	13	636
3351	291	13	625
3386	338	14	613
3421	392	32	602
3456	453	34	591
3491	524	36	580
3526	604	39	569
3561	695	41	557
3596	802	42	545
3631	923	46	536
3666	1059	48	525
3701	1213	50	513
3736	1388	52	503
3771	1590	54	493
3806	1821	57	482
3841	2088	59	471
3876	2394	61	459
3911	2744	64	449
3946	3143	67	439
3981	3594	70	428
4016	4102	73	417
4051	4672	76	407
4086	5308	80	398
4121	6014	84	388
4156	6796	86	380
4191	7660	89	371
4226	8616	92	361
4261	9672	93	352
4296	10837	96	344

small focus			
If (A)	Ie (µA)	boost time (s)	blank time (s)
3177	100	0	712
3209	122	2	684
3241	145	3	663
3273	171	5	643
3305	199	7	623
3337	231	9	606
3369	267	10	590
3401	309	12	573
3433	357	12	558
3465	413	12	545
3497	477	12	530
3529	550	21	515
3561	633	38	503
3593	727	43	489
3625	834	44	476
3657	953	47	464
3689	1087	51	451
3721	1238	53	440
3753	1409	55	429
3785	1602	58	418
3817	1822	61	405
3849	2070	64	395
3881	2349	68	383
3913	2662	71	372
3945	3011	73	362
3977	3400	76	353
4009	3831	79	343
4041	4308	82	333
4073	4832	86	324
4105	5407	90	316
4137	6041	93	307
4169	6743	95	299
4201	7524	98	290
4233	8394	101	280

4331	12122	99	335
4366	13535	102	327
4401	15085	104	319
4436	16784	106	312
4471	18646	109	305
4506	20690	112	297
4541	22934	115	289
4576	25395	117	283
4611	28092	119	276
4646	31042	123	269
4681	34263	126	261
4716	37765	128	255
4751	41554	130	248
4786	45637	134	242
4821	50020	136	237
4856	54710	139	230
4891	59712	143	225
4926	65037	144	218
4961	70714	147	214
4996	76790	150	209
5031	83306	152	203
5066	90309	155	198
5101	97840	159	192
5136	105945	162	188
5171	114655	164	183
5206	123976	168	177
5241	133907	171	171
5276	144446	173	166
5311	155593	177	162
5346	167348	181	157
5381	179701	184	152
5416	192596	186	148
5451	205961	191	144
5486	219721	193	138
5521	233806	197	135
5556	248141	199	129
5591	262651	204	125
5626	277250	207	122
5661	291850	211	117
5696	306361	213	113
5731	320696	217	110
5766	334764	222	107
5801	348463	225	103
5836	361676	229	100
5871	374286	233	96
5906	386174	237	93
5941	397222	241	89
5976	407369	248	87
6011	416660	253	82
6046	425153	260	80
6081	432904	267	77
6116	439968	276	73
6151	446342	284	69
6186	451943	294	65
6221	456685	305	63
6256	460480	313	58
6291	463297	322	56
6326	465420	325	52
6361	467246	329	46
6396	469169	335	40
6431	471551	343	32
6540	481407	372	0

4265	9362	103	270
4297	10438	105	262
4329	11633	109	254
4361	12954	112	246
4393	14405	115	237
4425	15987	117	230
4457	17704	120	222
4489	19558	122	215
4521	21552	126	208
4553	23687	129	201
4585	25970	131	194
4617	28416	134	188
4649	31045	138	181
4681	33875	141	176
4713	36926	143	170
4745	40216	146	164
4777	43766	150	157
4809	47592	152	151
4841	51711	154	147
4873	56136	158	140
4905	60882	161	135
4937	65963	163	128
4969	71394	167	124
5001	77188	170	119
5033	83359	174	113
5065	89914	176	109
5097	96865	180	102
5129	104220	183	99
5161	111990	186	93
5193	120185	188	88
5225	128812	193	85
5257	137880	195	80
5289	147397	199	74
5321	157369	203	71
5353	167804	206	65
5385	178709	209	61
5417	190067	212	58
5449	201837	215	54
5481	213980	220	50
5513	226455	223	45
5545	239224	227	42
5577	252238	230	38
5609	265434	234	33
5641	278741	238	31
5673	292087	242	26
5705	305403	246	22
5737	318628	249	20
5769	331763	253	15
5801	344832	259	13
5833	357856	263	9
5865	371094	268	4
5897	382000	273	0

Once the adaptation process is finished the filament current the boost process during turn-on or after tube switch-over looks like this:



First the large, then the small focus will be boosted for 3 seconds with the **Ifmax** value from the default data table. Afterwards the filament current will be decreased to 500mA for a certain time (from the calculation table now present) to bring it down to the 100µA based standby filament temperature.

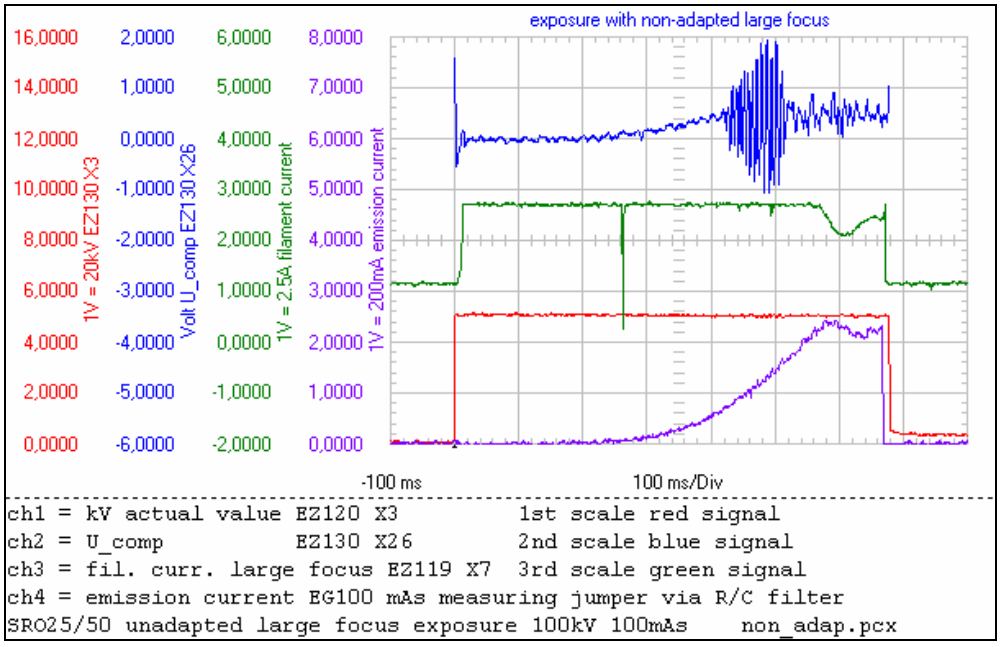
Only in this condition = both filaments adapted one might see at glass tubes that the filament is getting brighter with PREP.
Non-adapted filaments will not get a higher filament current with PREP.

Appendix A

mA_control EZ119 functions
conditioning mode

Systems with a non-adapted tube can be used at least with kV-mAs technique. The control desk displays “Test” in this condition.

It does not behave like the normal mAs technique with a constant mA value and the shortest time possible, but will get the user the required mAs and dose.



As one can see in the screenshot the filament current (green) jumps from 3A in PREP to the large focus filament current limit value 6.54A about 10ms after kV actual (red) is at its nominal value and **kV_control EZ130** has sent the X_ACT_S/ signal.

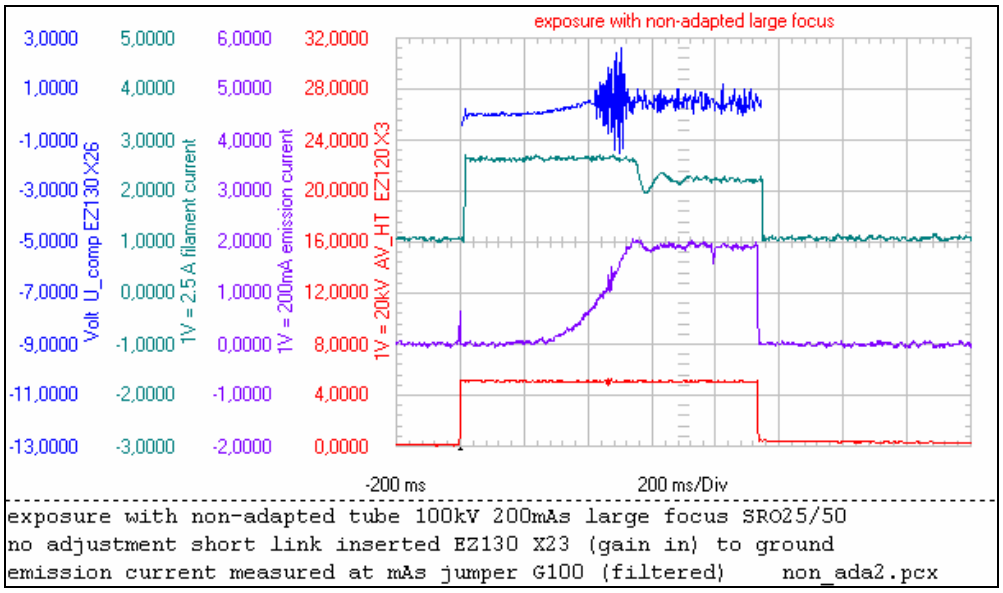
At 3A filament current the emission current is almost zero (< 100µA). Depending on the size and construction of the filament it takes quite a while before the temperature of the filament and with it the emission current (purple) rises.
If the emission current limit for the selected kV value is achieved the filament current will be reduced to keep the emission current at a constant value.
For all non-AEC techniques (kV-mAs, kV-mA-ms, kV-mAs-ms**) mA_control EZ119** always takes care about the termination of exposures once the set mAs value is achieved.

This technique can and should be used to condition the tube before it will be adapted during a non-preinstalled installation or after tube exchange.

The 4th signal (blue) of the screenshot displays the U_comp value (measured at the **kV_control EZ130** at release 3 generators only) to indicate that there is a lot of control to keep the kV at a constant level during a changing load.
Once the mA value is more or less stable U_comp is less busy.

The following screenshot shows the same, but instead of 100mAs for the first exposure 200mAs were set in this case. It results in a longer exposure time. Compared with the total exposure time it is only 250ms longer compared to the first exposure, which already took 675ms.
The reaction time to start with the emission of mA is the same, about 250ms.

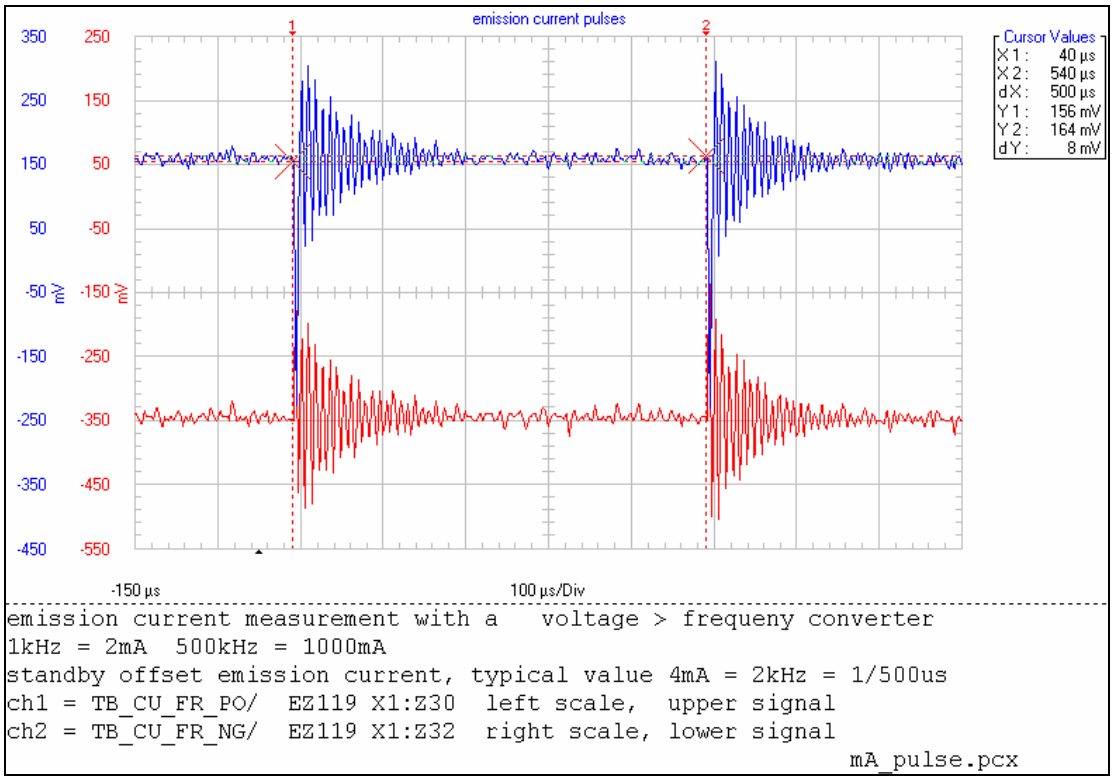
The emission current limit was set to 500mA in the first 100mAs exposure. For 200mAs it is limited to 400mA, otherwise the focus track will be overloaded.



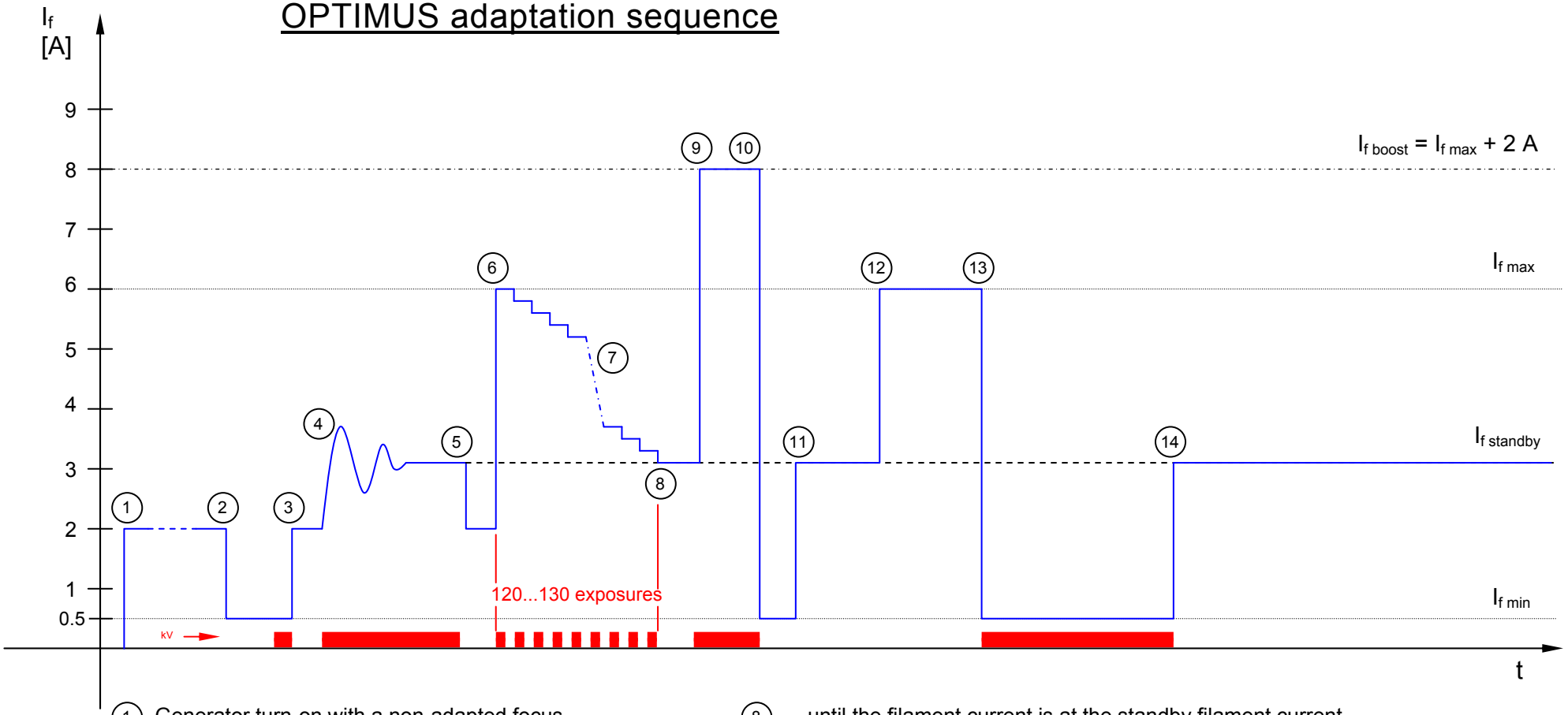
Warm-up or conditioning procedures must always be carried out with the large focus.
Some small filaments are very short. It takes so long to get it heated up to achieve an emission current that the generator errors out before any emission current appears.

Appendix B

Waveform of the offset "standby emission current"



OPTIMUS adaptation sequence



1. Generator turn-on with a non-adapted focus.
2. Adaptation start, measuring of the 4mA standby offset ...
3. ... emission current and offset mA of the kV meas. circuit.
4. Measuring of the individual standby filament current ...
5. ... based on 100µA emission current, 6 seconds exposure.
6. Measuring of the kV dependent emission currents ...
7. ... starting at the max filament current with decrements ...
8. ... until the filament current is at the standby filament current.
9. Measuring of the positive boost time to get the filament temperature...
10. ... = mA up from standby to achieve the selected mA value.
11. Timeout at 500mA to get the filament temperature down.
12. The filament is heated up with its max current, then the cooling ...
13. ... behavior (negative boost) takes place to measure the time...
14. ... it takes to decrease the mA down to its basic value of 100µA